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The controlling variables in landscape evolution: numerical modelling of the Australian Great Artesian Basin since the Jurassic

Carmen Braz (1), Gregory Smith (2), Ritu Gupta (2), Sabin Zahirovic (1), and Dietmar Müller (1)

(1) EarthByte Group, School of Geosciences, The University of Sydney, Sydney, Australia (carmen.braz@sydney.edu.au), (2) School of Earth & Planetary Sciences, Curtin University, Perth, Australia

Inundation of interior eastern Australia during the Early Cretaceous by the epicontinental Eromanga Sea produced extensive shallow marine deposits throughout the Eromanga, Surat, Carpentaria, and Clarence-Moreton basins. These sediments form the Great Artesian Basin (GAB) that underlies ∼22% of the Australian continent, becoming progressively non-marine through the mid Cretaceous despite rising eustatic sea levels. Geodynamic modelling suggests that dynamic topography, the long-wavelength low-amplitude subsidence and uplift caused by mantle flow, is an important factor in the inundation and retreat of the Eromanga Sea. Eastward migration of Australia over subducted oceanic lithosphere from the eastern Gondwanan margin caused ∼300-500 m of subsidence through the Jurassic and Cretaceous, followed by a rebound of ∼400-600 m since the Late Cretaceous as a result of cessation of subduction at ∼100 Ma. The time-dependent surface processes of erosion and deposition have been linked with the effects of dynamic topography using the landscape evolution code Badlands, modelled at the continental scale. The modelling assesses the effect of variables including paleo-topography, rainfall, uplift, erodibility, sea level, and lithosphere elastic thickness.

The large number of variables with uncertain ranges produces thousands of possible scenarios and iteratively testing each combination is not practical, requiring enormous computational time to find the controlling variables and measure their effects. Hence, Experimental Design and Analysis was used to determine the minimum number of scenarios necessary to capture and assess the significant effects. This gave a probability distribution of all possible scenarios and statistical measures for the relative importance of each parameter. The modelling of the observed sedimentation and burial history of the GAB indicates the primary controls on sediment volume are sea level and uplift of a volcanic belt along the eastern margin, whereas rainfall and initial topography are suggested to be not as important. The location of major depocentres is influenced by the effective lithospheric elastic thickness. The large volcanogenic influx from the eastern margin serves as the primary sediment source for the basin, in the preferred model depositing >2 km of sediment in the primary Eromanga depocenter as observed at the present day. The modelled inundation history of the continent is also consistent with paleogeographic reconstructions, showing an initial eastward incursion of the Eromanga Sea from the east, progressing towards a northern connection to the Gulf of Carpentaria through the Cretaceous and eventual retreat in response to dynamic topography. Stratigraphic cross sections with interpreted depositional environments based on paleo-depth, ranging from shallow marine to fluvial environments, broadly match observed stratigraphy in the GAB.